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| 09/894,627 | 06/28/2001 | John T. Boland | 82531DMW | 6130 |

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Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. 09/894,627 | Applicant(s) BOLAND ET AL. | |
|---|---|---|---|
| | Examiner Kevin Siangchin | Art Unit 2623 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1-15* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-15* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *26 August 2001* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *2 and 4 /*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

# Detailed Action

## *Drawings*

Objections

1. The drawings are objected to because of the following.

   a. In Figure 1, the caption in block 30 reads, "Determine Mis-Alignment of Control". To more adequately reflect the description of the associated step, the caption should be changed to "Determine Mis-Alignment of Control Features".

The handwritten captions of the Applicant's drawings, though marginally legible, should be replaced with typed captions. A proposed drawing correction or corrected drawings are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

## *Claims*

Objections

2. Claims 1 and 9 are objected to because of the following informalities. In step (a) of claim 1 and item (a) of the claimed digital processor of claim 9, the Applicant states, "where the object includes common surface features". Since only one object is being referred to in these claims, it is not clear what these surface features are common to, or how they are common. It seems, therefore, that the applicant intended to state, "where the object *images* include common surface features" or "where the *images of the* object include common surface features". Changes should be made to claims 1 and 9 to reflect this.

3. Claim 6 is objected to because of the following. Claims 6 refers to the "the alignment of the common features of *the aligned dental model* to like features on the image of the object". It is unclear whether the Applicant is referring, in this case, to the photogrammetrically aligned 3D model, derived

according to step (c) of claim 1, or the aligned dental model, derived according to step (d) of claim 1. It will be assumed hereinafter that the Applicant intended the former. This assumption is proper because the dental model obtained according to step (d), being the final result of the claimed method, should not require additional alignment. The language of claim 6 should be changed to explicitly indicate this. Appropriate correction is required.

Rejections Under 35 U.S.C. § 102(e)

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

5. Claims 1-3, 5-11, and 13-15 are rejected under 35 U.S.C. 102(e) as being anticipated by Rubbert et al. (U.S. Patent 6,648,640).

6. *The following is in regard to Claim 1.* Rubbert discloses a method and system for obtaining a complete three-dimensional virtual model of the dentition from a collection of dentition images (Rubbert et al. Abstract). The method disclosed by Rubbert et al. includes the following steps

(1.a.) i. Capturing a series of images of an intra-oral object (i.e. the dentition – see, for example, Rubbert et al. column 7, lines 56-58 and column 8, lines 9-12) from a plurality of capture positions (Rubbert et al. column 21, lines 1-5 and column 24. lines 17-18).

ii. The object images[1] include common surface features. These features can be taken to include the patterns projected onto the scanned object during scanning (e.g. Rubbert

1 See the objection to this claim above.

et al. column 24, lines 17-21) and/or structural features of the dentition common to the captured images. The latter set of features is implicit to Rubbert et al.'s image registration[2] process (e.g. Rubbert et al. column 40, lines 40-45 and Fig. 36).

iii. A control target is arranged with respect to the object to provide a control feature. Rubbert et al. suggest the usage of such a control target(s), referred to as a *landmark*, as the point(s) used in the aforementioned registration (Rubbert et al. Fig. 57, reference number 302 and column 49, lines 5-10).

(1.b.) Measuring the control features from the images of the control target (i.e. landmarks) included with the images of the object (e.g. Rubbert et al. column 49, lines 27-28). The object space (3D) coordinates of these points are also derived (Rubbert et al. Fig. 6, step 84).

(1.c.) i. Analytically generating a 3-dimensional model of the object by photogrammetrically[3] aligning the measurements of the control features. Generally, the method of Rubbert et al. derives 3D point-clouds (referred to henceforth as per-image point clouds or per-image models) for each of the captured set of images(Rubbert et al. Fig. 6, step 84). The overall 3D model of the dentition is obtained by performing an image registration process on the set of images (e.g. Rubbert et al. column 38, lines 63-67 to column 39, lines 1-3). In the case that landmarks are used, these points are used in the registration (e.g. Rubbert et al. column 49, lines 5-10).

ii. This provides a photogrammetrically aligned 3-dimensional model of the object (see above).

iii. Rubbert et al.'s registration yields a model that is a "best-fit" with respect to the

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2 Image registration is typically defined as the process of spatially aligning a set of images of an object.

3 "Photogrammetry is the art, science, and technology of obtaining reliable information about physical objects and the environment through the processes of recording, measuring, and interpreting photographic images and patterns of electromagnetic radiant energy and other phenomena" [1]

varying captured images (e.g. Rubbert et al. column 40, lines 40-45). That is, the derived 3D model is such that the image errors due to the variable orientations of the capture positions are reduced to some predetermined optimality threshold (e.g. the THRESHOLD of Fig. 48A, step F).

(1.d.) i. According to Rubbert et al.'s cumulative registration procedure (i.e. step 196 of Rubbert et al. Fig. 36), the photogrammetrically aligned 3-dimensional model of the object is adjusted by aligning the common features of the model to like features on an image of the object (i.e. image or frame registration). In one manifestation of this procedure, "each frame in the set of frames is registered to a cumulative registration 3-dimensional model of the object" (Rubbert et al. Fig. 53 and column 47, lines 18-35). See also Figs. 48A-48C

ii. Cumulative registration produces an aligned dental model from the series of images, as illustrated above.

It has thus been shown that Rubbert et al.'s method and system for obtaining a complete three-dimensional virtual model of the dentition sufficiently conforms to the dental modeling method proposed by the Applicant in claim 1. Therefore, the teachings of Rubbert et al. anticipate the dental modeling method put forth in claim 1.

7. *The following is in regard to Claim 2.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 1. It should be clear from the preceding discussion that the common features of step (1.b) above are measured from the series of images of the object. See the discussion above with regard to (1.a)-(1.b). Taking this into account, the modeling method of Rubbert et al. conforms to that which is proposed by the Applicant in claim 2. In this manner, the teachings of Rubbert et al. anticipate the dental modeling method put forth in claim 2.

8. *The following is in regard to Claim 3.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 1. As mentioned above, step (1.c) involves performing a photogrammetric adjustment (e.g. photogrammetric alignment). This adjustment is sequentially refined to a predetermined *closeness factor* (Rubbert et al. Fig. 40A, steps 12-13) by:

(3.a.) Photogrammetrically projecting a 3-dimensional model of the image (e.g. the per image 3D model – Rubbert et al. Fig. 6, Step 84) onto another image(s), or more specifically another per-image model(s), through the application of a derived transformation matrix (Rubbert et al. column 23, lines 23-27 and column 41, lines 7-12).

(3.b.) Determining the misalignment, represented as *minimum distance vectors* (Rubbert et al. Fig. 40A, step 1 and column 41, lines 53-57), of the control features and correcting the misalignment by successive iterations of the procedure depicted in Rubbert et al. Figs. 40A-40C, until the square root of the sum of the squared minimum distance vectors attains a desired closeness factor (Rubbert et al. column 44, lines 22-33).

This process produces a "photogrammetrically aligned" 3-dimensional model of the object. It has thus been shown that Rubbert et al.'s method and system for obtaining a complete three-dimensional virtual model of the dentition sufficiently conforms to the dental modeling method proposed by the Applicant in claim 3. Therefore, the teachings of Rubbert et al. anticipate the dental modeling method put forth in claim 3.

9. *The following is in regard to Claim 5.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 1. As indicated by Rubbert et al. (Rubbert et al. column 5, lines 60-63), the disclosed system and method "can be considered an interactive, computer-based computer aided design and computer aided manufacturing (CAD/CAM) system [and method] for orthodontics". See also Part 5. Appliance Manufacturing of Rubbert et al.'s disclosure (Rubbert et al. column 71). For example, the derived 3D model of Rubbert et al.'s method and system is supplied to a stereolithography system that manufactures a plastic model of the teeth (Rubbert et al. column 72, lines 26-29). In this way, the modeling method of Rubbert et al. conforms to that which is proposed by the Applicant in claim 5. The teachings of Rubbert et al., therefore, anticipate the dental modeling method put forth in claim 5.

10. *The following is in regard to Claim 6.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 1. Rubbert et al. further suggest providing a database of generic 3-dimensional models (i.e. *three dimensional virtual template tooth objects* – see Rubbert et al. column 50, lines 38-40 – and/or the *library of standardized template teeth* – see Rubbert et al. column 53, lines 49-67). A selected tooth template is aligned (scaled and oriented) to the per-image

models (Rubbert et al. column 50, lines 44-67 to column 51, lines 1-22). Since the per-image model is photogrammetrically aligned to scanned images, the common features of the selected template model are aligned to like features on the image of the object (e.g. the corresponding "real" tooth). The result of this "template fitting" process is a 3D dental model aligned to the series of images. This process supplements the of the procedures (i.e. cumulative registration) defined in (1.d) above (Rubbert et al. column 50, lines 17-29). In summary, Rubbert et al. suggests providing a database of generic 3-dimensional models and utilizing a selected one of these generic models in step (1.d) in the alignment of the common features of the aligned dental model to like features on the image of the object. In this way, the modeling method of Rubbert et al. conforms to that which is proposed by the Applicant in claim 6. The teachings of Rubbert et al., therefore, anticipate the dental modeling method put forth in claim 6.

11. *The following is in regard to Claim 7.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 1. It should be clear from the figures of Rubbert et al. (e.g. Rubbert et al. Fig. 57) that, in the dental modeling method of Rubbert et al., the intra-oral object is one or more teeth. Therefore, the modeling method of Rubbert et al. conforms to that which is proposed by the Applicant in claim 7. In this way, the teachings of Rubbert et al. anticipate the dental modeling method put forth in claim 7.

12. *The following is in regard to Claim 8.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 7. It should be clear from Rubbert et al. Fig. 57 that the control target (i.e. landmark(s) 302) is positioned around[4] one or more teeth. Therefore, the modeling method of Rubbert et al. conforms to that which is proposed by the Applicant in claim 8. In this way, the teachings of Rubbert et al. anticipate the dental modeling method put forth in claim 8.

13. *The following is in regard to Claims 9-11, 13, and 14-15.* Claims 9-11, 13, and 14-15 recite substantially the same limitations as claims 1-3, 5, and 7-8, respectively. (These claims merely propose systems implementing the corresponding methods of claims 1-3, 5, and 7-8). Therefore, with regard to

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4 *Around* is being interpreted here as *near*, or *in approximate location to*.

claims 9-11, 13, and 14-15, remarks analogous to those presented above with regard to claims 1-3, 5, and 7-8 are respectively applicable.

Rejections Under 35 U.S.C. § 103(a)

14. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

15. Claims 4 and 12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Rubbert et al. in view of Snow (U.S. Patent 6,068,482).

16. *The following is in regard to Claim 4.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 1. The cumulative registration process (step (1.d) above) of Rubbert et al. includes:

($4.a_1$) Determining misalignment of the common features in the photogrammetrically aligned 3-dimensional model relative to the images determining misalignment (e.g. *minimum distance vectors* – see the discussion above with regard to claim 3) of the common features in the photogrammetrically aligned 3-dimensional model relative to the images by photogrammetrically projecting the model *onto another frame*, or more specifically, *onto another per-image model.*

($4.b_1$) Applying a 3-dimensional morphing algorithm to correct for the misalignment (as noted earlier with respect to claim 3 (step (3.b)).

Though a frame or per-image model, according to the method of Rubbert et al., is representative of an image of an object, Rubbert et al. do not expressly indicate that the projection of the photogrammetrically aligned 3-dimensional model should be onto an image of the object. Consequently, the 3-dimensional morphing does not necessarily involve adjusting the photogrammetrically aligned 3-dimensional model *to an image(s) of the object*, according to the Applicant's disclosed definition of morphing, but rather involves

adjusting the photogrammetrically aligned 3-dimensional model to a per-image model(s) of the object, derived and representative of an image(s).

17. Snow disclose a method for the creation and utilization of 3D teeth models. The method of Snow involves:

($4.a_2$) Visually superimposing (i.e. photogrammetrically projecting) an initial three-dimensional computerized tooth model onto the two-dimensional image of the patient's teeth. Note that, since the initial 3D model is subsequently aligned (step 4.b below)according to the corresponding 2D image, the misalignment of features common to the projected model and the 2D image is inherently measured.

($4.b_2$) Interactively adjusting the three-dimensional teeth so that they are aligned with the two-dimensional image – in other words, applying a 3-dimensional morphing algorithm – to correct for the misalignment. Note that since adjustment to the 3D model is made with respect to a 2D image, the 3D morphing performed in Snow's method is analogous to that of the Applicant.

See the Abstract of Snow and column 3, lines 29-35 and 38-56. Furthermore, Snow suggests that the steps ($4.a_2$) and ($4.b_2$) above may be automated. See Snow column 5, lines 4-6.

18. The teachings of Snow and Rubbert et al. are combinable because they are analogous art. Specifically, the teachings of both Snow and Rubbert et al. are concerned with 3D dental modeling systems and methods that refine derived 3D dental models through the observation and analysis of corresponding 2D dental images. Therefore, it would have been obvious to one of ordinary skill in the art, at the time of the applicant's claimed invention, to determine the aforementioned misalignment by projecting the photogrammetrically aligned 3-dimensional model, derived according to step (1.c)-(1.d) of Rubbert et al.'s method, onto a corresponding 2D dental image(s) and to subsequently correct the misalignment by 3D morphing, in accordance with the method of Snow. The motivation for doing so would have been to eliminate or reduce the computation burden of performing the cumulative registration (Rubbert et al. Fig. 36, step 196) of Rubbert et al. Combining the teachings of Snow and Rubbert et al., in this manner, would have yielded a method for dental modeling that conforms to the dental modeling method of claim 4.

19. *The following is in regard to Claim 12.* As shown above, Rubbert et al. disclose a dental modeling method that conforms to the modeling method proposed in claim 9. Claim 12 recites substantially the same limitations as claim 4. (This claim merely proposes a system implementing the corresponding method of claim 4). Therefore, with regard to claim 12, remarks analogous to those presented above with regard to claim 4 are applicable.

### *Citation of Relevant Prior Art*

20. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure:

[1] *What is Photogrammetry?* [Retrieved from *http://www.123photogrammetry.com/photogrammetry.html* on June 30, 2004]. James R. Williamson, Ph.D. © 1999-2000.

Provides the standard definition of photogrammetry given by the American Society for Photogrammetry and Remote Sensing.

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Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kevin Siangchin whose telephone number is (703)305-7569. The examiner can normally be reached on 9:00am - 5:30pm, Monday - Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Amelia Au can be reached on (703)308-6604. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Kevin Siangchin

Examiner
Art Unit 2623
ks – 07/01/04

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